A fuzzy linguistic approach for stakeholder prioritization

Yasiel Pérez Vera[1][0000-0001-9421-9529] and Anié Bermudez Peña[2][0000-0002-1387-7472]

[1] La Salle University, Arequipa, Peru
[2] University of Informatics Science, Havana, Cuba
yasielpv@gmail.com

Abstract. A factor considered relevant to achieve a successful project is stakeholder management. The stakeholder prioritization process is usually carried out by the project manager manually using techniques such as interviewing, brainstorming and checklists. These techniques do not take into account the uncertainty introduced by the evaluations of multiple experts in the stakeholder classification process. The objective of this research is to propose a fuzzy linguistic approach for stakeholder prioritization. To do this, a study is made about the stakeholders prioritizing process, as well as the techniques to manage information with uncertainty in the decision analysis process. The steps of the proposed approach for stakeholder prioritization based on the linguistic 2-tuple model are described. An illustrative example is shown where the stakeholder prioritization is applied to a project to determine who the stakeholder is more important than another. The proposal is based on the computing with words paradigm that you can obtain more interpretable results firstly unifying the assessments of multiple experts into linguistic 2-tuple values and applying an accurate aggregation process that makes possible to generate a more accurate priority for the stakeholder in the project. Correct classification of the stakeholders allows to prioritize and attend to those that have greater importance for the project, allowing that actions are traced to avoid the negative impact and enhance their positive.

Keywords: Fuzzy Linguistic, Project Management, Stakeholders Prioritization.

1 Introduction

The failure of a project is directly related to the impression that the stakeholders have on the value of the project and the correct way of managing the relations between the stakeholders. The lasts public results in The CHAOS Report [1] clearly reflect that only 29% of software projects are considered satisfactory, the rest does not complete successfully. This study examines the aspects that are considered relevant to achieve a successful project and the great majority is directly related to the management of stakeholders [2].

The term stakeholder was developed by Edward Freeman in 1984, where he defined stakeholders as groups or individuals that may affect or be affected by the achievement of the company's goals [3]. According to the author, these groups should be considered as an essential element in the strategic planning of the organization [4].

The management of stakeholders in a project includes the processes necessary to identify them, analyze their expectations and impact on the project, and develop appropriate management strategies to enable them to participate effectively in decision-making. A correct identification, classification and prioritization of stakeholders helps the project manager to focus on the relationships necessary to ensure project success [5].

The stakeholder prioritization process is usually carried out by the project manager using techniques such as interviewing experts, brainstorming and checklists [6]. There are several methods [7–10] that use different attributes to prioritize stakeholders. It is not possible or viable to choose a method as the best or the most effective since it is the characteristics of the project, the work team and the stakeholders themselves that determine it.

These methods are based on a subjective assessment of experts on the possession of attributes by the stakeholders that is usually qualitative. This introduces a certain degree of uncertainty in the prioritization process since each expert has a different appreciation on the subject. Another difficulty is that it does not establish any mechanism for the treatment of the valuations of multiple experts, which leads to loss of time and information to achieve a convergence between valuations. When this level of uncertainty is not taken into account and the appropriate methods are used for its processing, there is a loss of information that affects the accuracy of the result.

To overcome such limitations this paper proposes a new approach for the stakeholder prioritization process, which provides a flexible evaluation framework capable of gathering assessments taking into account the uncertainty of the experts' criteria. The uncertain information will be managed by a fuzzy linguistic approach [11] that implies the necessity of Computing With Words (CWW) processes [12, 13]. It is remarkable that this approach not only obtains accurate and understandable results but also it will calculate the priority by a multi-step aggregation procedure whose outcomes will be accurate and interpretable.

This paper is structured as follows. Section 2 reviews the main characteristics of stakeholder prioritization process and traditional solving methods. Subsequently Section 3 revises approaches to deal with uncertain information and select the suitable for those problem. Section 4 introduces the new approach for stakeholder prioritization based on the linguistic 2-tuple model for dealing with uncertain information. Section 5 shows an illustrative example and Section 6 concludes the paper. Finally, Section 7 introduces future work that would be necessary to deepen in order to improve and generalize the proposed approach.

2 The stakeholder prioritization process

Techniques for stakeholder prioritization are aimed at grouping the stakeholders of a project according to their characteristics, functions, expectations, interests and influences. Once their quantitative and qualitative information has been identified and collected, the stakeholders are classified in order to guarantee the efficient use of the effort to communicate and manage their expectations. The initial evaluation should be reviewed and updated regularly as the number of stakeholders varies depending on the project size, type and complexity. This allows the project manager to concentrate on the relationships necessary to ensure the project success [14].

Several techniques are based on a series of attributes and the possession or not of these attributes to establish the categories that segment the spectrum of stake-holders of the project. The attributes or characteristics are given by the interrelation of the stakeholders with the project or with other stakeholders [15].

Among the attributes that take into account the techniques of stakeholder prioritization are: interest in the success (or not) of the project, level of decision, power it exercises over the project, the urgency of the requests made to the project and belonging to the organization. As part of the investigation, some techniques for the stakeholder classification are analyzed [16–21].

Generally, techniques for classification of stakeholders have evolved from simple methods and with few attributes more complex methods. Techniques Gardner [16] Savage [17] Clarkson [18] and Friedman [20], they are biased in the stakeholder analysis since only raise the relationship between two variables, leaving address key aspects of the relationship between stakeholders and the project.

The Mitchell Prominence Model [19] defines the stakeholder classification based on a diagram in which relate the variables power, legitimacy and urgency. The power is the ability of the stakeholder to influence the project; legitimacy refers to the relationship and actions of the stakeholder with the project in terms of desirability, property or convenience; and the urgency refers to the immediate attention to the stakeholder's requirements by the project.

According to several investigations [22–26], this model is one of the most discussed and used in the world. This model is considered to be operable, since it allows the stakeholders identification to the extent that the amount of power, legitimacy and urgency they possess can be assessed. Due to the characteristics and advantages provided by the use of the Mitchell technique for the stakeholder classification in the projects, it is decided to choose it as the base method in the investigation.

In [7] the identification, prioritization and classification of stakeholders is done using Mitchell's prominence model. In [9] a method for the prioritization of stakeholders based on operations with fuzzy sets is described. The proposed method defines eleven attributes measured at different scales that profile each stakeholder. Once the values are normalized, the fuzzy operations of union and intersection of sets are applied, obtaining a numerical value that serves to order the stakeholders. This proposal does not classify the stakeholders, it only prioritizes them by adding the assessments made by experts, once normalized, of the defined attributes.

In [27] a method is proposed using the Analytical Hierarchical Process (AHP) that allows to prioritize the stakeholders of a project. This method orders them according to the criteria of importance for the organization and satisfaction of the requests of the stakeholder, although it does not propose classifications or take into account the treatment of the uncertainty in the information provided by the experts.

In the analyzed researches, techniques are proposed that do not take into account the uncertainty management that provides the human perception of the characteristics of each stakeholder in the project. Nor is there an opportunity for several experts to give their opinion on the stakeholder classification.

3 Management of uncertain information in decision analysis processes

This section firstly reviews the decision analysis process to provide the means for managing uncertain information; secondly presents a revision about the fundamentals and use of the 2-tuple linguistic representation model.

3.1 The decision analysis process

The decision analysis [28] is a suitable approach for evaluation and prioritizing processes. Its main purpose is to support the decision-making process by providing the relevant and effective elements to the decision makers in a rational, intuitive and ordered mode. It supplies methods for organizing decisions by firstly establishing the set of appraised elements in the evaluation framework, then gathering the information and finally, computing a final assessment for each element. These phases are depicted in Fig. 1.

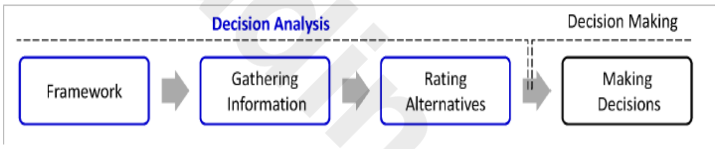

Fig. 1. The decision analysis scheme.

The stakeholder prioritization process is usually considered a multi-attribute and multi-expert decision-making problem since several experts give their opinion on various attributes of stakeholders in the projects.

There are different models to perform the CWW processes. Initially, in the fuzzy linguistic approach, the so-called classics were used: a model based on the extension principle and the symbolic one. The first is considered accurate, but difficult to interpret, although it can be interpreted at the expense of its accuracy. However, the second is easily interpretable, but presents information loss in their computational processes [30]. To overcome these limitations other symbolic computational models have been proposed that improve the accuracy of classical computational models, some of the most widespread being the 2-tuple linguistic model [11], the virtual linguistic model [31] and the proportional 2-tuple linguistic model [32].

The 2-tuple model is easy to understand and maintains a fuzzy representation of the linguistic information where its results are assigned a syntax and semantics. This linguistic model is feasible for the treatment of the uncertainty associated to the prioritizing of the stakeholders on the projects. To guarantee the accuracy of the 2-tuple model, it is necessary to use a set of labels symmetrically and evenly distributed. It is also important to highlight that this model is widely used in problems of evaluation, classification, prioritization and ordering of alternatives [11, 28, 33–36].

In the coming subsection is described the 2-tuple linguistic representation model that will be used in the management of uncertain linguistic information to prioritize the stakeholders.

3.2 2-Tuple linguistic representation model for CWW

This computational model was presented in [11] with the aim of improving the accuracy of CWW, in addition to expressing in a symbolic way any result in the universe of discourse. This model has subsequently been used satisfactorily for the treatment of multigranular linguistic information, unbalanced linguistic information and heterogeneous information (numerical, interval and linguistic).

Let $\mathrm{S} = \{S_0, \ldots, S_g,\}$ be a set of linguistic terms, and $\beta \in [0, g]$ a value obtained by a symbolic operation. The symbolic translation of a linguistic term $S_i \in \{S_0, \ldots, S_g,\}$ is a numerical value defined in $[-0.5, 0.5)$ that represents the "information difference" between a quantity of information $\beta \in [0, g]$ obtained of a symbolic operation and the index of the closest linguistic term [11].

From this concept, a new model of representation for linguistic information was developed, which uses a 2-tuple as a basis for representation. Each 2-tuple is represented by (S_i, α) where $S_i \in \{S_0, \ldots, S_g,\}$ corresponds to the linguistic term and $\alpha \in [-0.5, 0.5)$ which symbolizes the numerical value that constitutes the distance from the original result $\beta \in [0, g]$ to the index of the nearest linguistic term S_i.

To obtain the linguistic 2-tuple that expresses the information contained in β, in [11] it is proposed to use the formula $\Delta(\beta) = (S_i, \alpha)$, where $i = round(\beta)$ and $\alpha = \beta - i$. It should be noted that Δ is bijective and that therefore $\Delta^{-1}: \langle S \rangle \rightarrow [0, g]$ is defined as $\Delta^{-1}(S_i, \alpha) = i + \alpha = \beta$; leaving the 2-tuple in $\hat{\mathrm{S}}$ identified with a numerical value in the interval $[0, g]$. Bearing this in mind, to convert a linguistic term into a linguistic 2-tuple, a value of 0 must be added as a symbolic translation, leaving $S_i \in S \rightarrow (S_i, 0) \in \hat{\mathrm{S}}$.

The comparison of linguistic information represented by 2-tuples is done according to a lexicographic order. Let (s_k, α_1) and (s_l, α_2) two 2-tuples, each representing a quantity of information, so if $k < l$ then $(s_k, \alpha_1) < (s_l, \alpha_2)$, if $l < k$ then $(s_l, \alpha_2) < (s_k, \alpha_1)$. If $k = l$ then the 2-tuple greater will depend on the value of its symbolic translation. If $\alpha_1 < \alpha_2$ then $(s_k, \alpha_1) < (s_l, \alpha_2)$, if $\alpha_2 < \alpha_1$ then $(s_l, \alpha_2) < (s_k, \alpha_1)$ and if $\alpha_1 = \alpha_2$ then $(s_k, \alpha_1) = (s_l, \alpha_2)$ [11].

Aggregation consists of obtaining a collective value that expresses the information of a set of marginal values. The result of an aggregation operation must be consistent with the representation of the input values, therefore, the result of the aggregation of 2-tuples must be a 2-tuple. Below we review some aggregation operators on 2-tuples that were defined in [11].

The arithmetic mean (AM) is an aggregation operator to determine the balance point or center of the set of values. For a set of 2-tuples $x = \{(s_1, \alpha_1), \ldots, (s_n, \alpha_n)\}$, the extension for 2-tuples model of this operator is obtained as follows in Equation 1.

$$\bar{x}^e(x) = \Delta\left(\frac{1}{n}\sum_{i=1}^{n}\Delta^{-1}\big((s_i,\alpha_i)\big)\right) = \Delta\left(\frac{1}{n}\sum_{i=1}^{n}\beta_i\right) \quad (1)$$

The weighted average (WA) allows the values x_i to have different importance, for which each value x_i must have an associated weight w_i that emphasizes its importance. So, for a set of 2-tuples $x = \{(s_1,\alpha_1),\dots,(s_n,\alpha_n)\}$ with a vector of weights associated with each 2-tuple, $W = (w_1,\dots,w_n)$, the extension for this operator is obtained as shown in Equation 2.

$$\bar{x}^w(x) = \Delta\left(\frac{\sum_{i=1}^{n}\Delta^{-1}(s_i,\alpha_i)\cdot w_i}{\sum_{i=1}^{n}w_i}\right) = \Delta\left(\frac{\sum_{i=1}^{n}\beta_i\cdot w_i}{\sum_{i=1}^{n}w_i}\right) \quad (2)$$

In the ordered weighted aggregation (OWA) operator, the weights are not associated to a predetermined value but to a determined position. So, if you have a set of 2-tuples $x = \{(s_1,\alpha_1),\dots,(s_n,\alpha_n)\}$ and $W = (w_1,\dots,w_n)$ is your associated weight vector such that $w_i \in [0,1]$ and $\sum w_i = 1$, the extension of the operator is obtained as shown in Equation 3, where β_j^* is the j-th highest value of the $\Delta^{-1}(s_i,\alpha_i)$.

$$OWA(x) = \Delta\left(\sum_{j=1}^{n} w_j \cdot \beta_j^*\right) \quad (3)$$

This model allows a simple process without loss of information where the result of the process is always expressed in the initial linguistic domain. This allows to improve the accuracy of its results by not having to carry out approximation operations. This computational model is precise when the representation of the semantics of linguistic labels is performed with triangular functions [37].

4 An approach for stakeholder prioritization based on the linguistic 2-tuple model

In this section is presented a new approach for stakeholder prioritization based on the linguistic 2-tuple model that deal with uncertain information. This approach has three steps that are described in further detail in the following sections.

First, all the elements of the approach are defined, including the experts, the stakeholders and its attributes. Then, the evaluation of the experts will be collected for each of the attributes defined for each stakeholder. Next, the evaluation of the experts to be used in the CWW linguistic model will be converted to 2-tuples. Then, the aggregation phase is followed, first by experts, where a collective evaluation will be obtained for each attribute for each stakeholder. Next, the collective evaluations will be aggregated by attribute, obtaining a single evaluation for each stakeholder that expresses the collective evaluation of all the experts for all the attributes. With a 2-tuple for each stakeholder, we proceed to order them using the 2-tuple comparison operators analyzed in the previous section. As an output of this approach, we will have a ranking list of project stakeholders that takes into account the uncertainty of the information provided by multiple experts.

4.1 Definition of approach's elements

All the elements of the approach are defined in the first step.

- Let $T = \{t_j | j \in (1, \dots, p)\}$ be a set of project stakeholders.
- Let $C = \{c_k | k \in (1, \dots, q)\}$ be a set attributes to evaluate for the stakeholder prioritization with de weighting vector $W^c = \{w_k^c | k \in (1, \dots, q)\}$, $w_k^c \in [0,1]$ with $\sum_{k=1}^{q} w_k^c = 1$.
- Let $E = \{e_l | l \in (1, \dots, r)\}$ be a set of experts with de weighting vector $W^e = \{w_l^e | l \in (1, \dots, r)\}$, $w_l^e \in [0,1]$ with $\sum_{l=1}^{r} w_l^e = 1$. Each expert e_l will be evaluate each attribute c_k for each stakeholder t_j using the evaluation vector $x_l^{jk} = \{x_1^{11}, \dots, x_r^{pq}\}$.
- Let $S = \{s_i | i \in (0, \dots, g)\}$ be a set of ordered linguistic terms where the representation of the semantics of linguistic labels is defined with triangular functions and $s_{i1} < s_{i2}$ for all $i1 < i2$. The evaluations of the experts x_l^{jk} are expressed using the set of linguistic terms S.

4.2 Recollection of expert's evaluations by attribute and its conversion to 2-tuple

Once the elements of the approach have been defined, preferences must be gathered as in Table 1. Each expert provides her/his evaluation over attribute by means of evaluation vector described previously.

Table 1. Expert evaluations by attribute

Stakeholders	Attributes	Expert e_1	…	Expert e_l
t_1	c_1	x_1^{11}	…	x_l^{11}
	…	…	…	…
	c_k	x_1^{1k}	…	x_l^{1k}
…	…	…	…	…
t_j	c_1	x_1^{j1}	…	x_l^{j1}
	…	…	…	…
	c_k	x_1^{jk}	…	x_l^{jk}

Then, it is obtained the linguistic 2-tuple from de evaluation provided by the experts for each attribute for each stakeholder. The Table 2 show the transformation.

Table 2. 2-Tuple expert evaluations by attribute

Stakeholders	Attributes	Expert e_1	…	Expert e_l
t_1	c_1	$(S_i, a)_1^{11}$	…	$(S_i, a)_l^{11}$
	…	…	…	…

	c_k	$(S_i,a)_1^{1k}$	$\cdots$	$(S_i,a)_l^{1k}$
$\dots$	$\dots$	$\dots$	$\dots$	$\dots$
t_j	c_1	$(S_i,a)_1^{j1}$	$\cdots$	$(S_i,a)_l^{j1}$
	$\dots$	$\dots$	$\dots$	$\dots$
	c_k	$(S_i,a)_1^{jk}$	$\cdots$	$(S_i,a)_l^{jk}$

4.3 Aggregation of evaluations by expert and attribute

The main objective of this step is to obtain a collective assessment based on individual assessments through the use of aggregation operators. It is carried out from the individual evaluation of the experts on the set of attributes by stakeholder to obtain a global evaluation for each attribute by stakeholder. Since each expert has an associated weight vector indicating the importance of his evaluation, the WA operator described in Section 3.2 is used to aggregate the expert evaluations as show in Table 3.

Table 3. Collective evaluation by attribute

Stakeholders	Attributes	Collective evaluation
t_1	c_1	$(S_i,a)^{11}$
	$\dots$	$\dots$
	c_k	$(S_i,a)^{1k}$
$\dots$	$\dots$	$\dots$
t_j	c_1	$(S_i,a)^{j1}$
	$\dots$	$\dots$
	c_k	$(S_i,a)^{jk}$

Later, it is obtained an evaluation for each stakeholder from the collective assessment by attribute obtained previously through the use of aggregation operators. Since each attribute has an associated weight vector indicating its importance, the WA operator described in Section 3.2 is used to aggregate the attribute collective evaluations as show in Table 4.

Table 4. Evaluation by stakeholder

Stakeholders	General evaluation
t_1	(S_i,a)
$\dots$	$\dots$
t_j	(S_i,a)

As the final evaluation of the stakeholder is obtained through a 2-tuple, its ordering is very simple using the 2-tuple comparison operator described in section 3.2. As a result of this step, a ranking list of project stakeholders that takes into account the uncertainty of the information provided by multiple experts is obtained. This list provides the stakeholder's priority above the rest of the project stakeholders.

5 An illustrative example

The stakeholder prioritization can be applied to any project to determine who the stakeholder is more important than another stakeholder. In this example the project to analyze has four stakeholders: employees (Stakeholder 1), product owner (Stakeholder 2), government (Stakeholder 3) and managers (Stakeholder 4). The set of attributes to evaluate for each stakeholder is defined in C = {Coercive power, Utilitarian power, Normative-social power, Social legitimacy, Organizational legitimacy, Temporal sensitivity and Criticism} with weighted vector $W^c = \{0.17, 0.17, 0.16, 0.1, 0.1, 0.15, 0.15\}$. These attributes are described following.

There are several attributes that describes the stakeholders, among which is the Mitchell prominence model [19]. In this research, power variable is associated with the disposition or possibility of obtaining coercive power (CP) through physical force or weapons, utilitarian power (UP) by means of technology, money, knowledge, logistics, raw materials and normative-social power (NSP) as prestige, esteem, charisma.

Legitimacy is considered as the presumption or generalized perception that the actions of a stakeholder [19]. Legitimacy can be measured based on the attributes: organizational legitimacy (OL) and social legitimacy (SL). Where the first expresses the attribution of a degree of desirability of the actions of the stakeholder at the organizational level and the second at the social level.

The urgency variable is defined as the degree to which stakeholders consider their claims to the project important [19]. In this context, they differentiate the degree of emergency possession according to the possession of two attributes: temporal sensitivity (TS) that is the degree of unacceptability on the part of the stakeholder in the delay of the manager in addressing their claims and criticism (C) manifests itself in the importance that stakeholders consider having their claims or issues.

A set of 5 linguistic terms is defined so that the experts issue their evaluation of the different attributes for each stakeholder. Let $S = \{s_0 = Very\ Low; s_1 = Low; s_2 = Moderated; s_3 = High; s_4 = Very\ High\}\ with\ s_i < s_j\ for\ all\ i < j$ as show in Fig. 2.

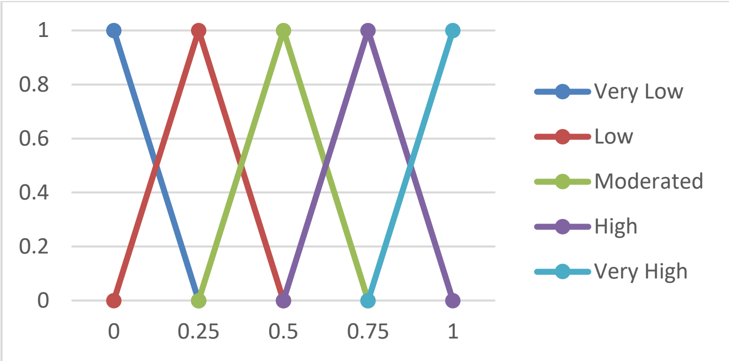

Fig. 2. Linguistic term set S^5

The experts committee is composed by three experts: the project manager (Expert 1), the SCRUM master (Expert 2) and the business analyst (Expert 3). The weighted vector associated to the experts is defined as $W^e = \{0.4,\ 0.35,\ 0.25\}$. The Table 5 show the expert's evaluation recollected for each attribute by stakeholder.

Table 5. Expert evaluations by attribute

Stakeholders	Attributes	Expert 1	Expert 2	Expert 3
Stakeholder 1	CP	Very Low	Very Low	Very Low
	UP	Low	Very Low	Very Low
	NSP	High	Very Low	Low
	SL	Moderated	Very Low	Moderated
	OL	Moderated	Very Low	Moderated
	TS	Low	Very Low	Very Low
	C	High	Very Low	Very Low
Stakeholder 2	CP	Very High	Very High	Moderated
	UP	High	High	Very High
	NSP	Very High	High	Very High
	SL	Very High	High	Very High
	OL	Very High	High	Very High
	TS	Very High	High	Very High
	C	High	High	Very High
Stakeholder 3	CP	Low	Moderated	Very Low
	UP	Low	Moderated	Moderated
	NSP	Moderated	Moderated	Low
	SL	Moderated	Moderated	High
	OL	Moderated	Moderated	Moderated
	TS	Low	Moderated	High
	C	High	Moderated	High
Stakeholder 4	CP	High	Very High	Low
	UP	High	High	Very High
	NSP	High	High	High

	SL	High	High	Very High
	OL	High	High	Very High
	TS	Very High	High	Very High
	C	High	High	Very High

Then, the evaluation of the experts must be transformed into the linguistic representation of 2-tuples in order to be able to process this evaluation. Once transformed into 2-tuples, the evaluation is aggregated. The WA operator is used since it is considered that the evaluations of the experts have different relevance expressed in the weighted vector. Table 6 shows the evaluations of stakeholders by the experts transformed into 2-tuples and the result of the aggregation process by experts.

Table 6. 2-Tuples experts' evaluation and collective evaluation for attribute

Stakeholders	**Attributes**	**Expert 1**	**Expert 2**	**Expert 3**	**Collective evaluation**
Stakeholder 1	CP	$(s_0, 0)$	$(s_0, 0)$	$(s_0, 0)$	$(s_0, 0)$
	UP	$(s_1, 0)$	$(s_0, 0)$	$(s_0, 0)$	$(s_0, 0.4)$
	NSP	$(s_3, 0)$	$(s_0, 0)$	$(s_1, 0)$	$(s_1, 0.45)$
	SL	$(s_2, 0)$	$(s_0, 0)$	$(s_2, 0)$	$(s_1, 0.3)$
	OL	$(s_2, 0)$	$(s_0, 0)$	$(s_2, 0)$	$(s_1, 0.3)$
	TS	$(s_1, 0)$	$(s_0, 0)$	$(s_0, 0)$	$(s_0, 0.4)$
	C	$(s_3, 0)$	$(s_0, 0)$	$(s_0, 0)$	$(s_1, 0.2)$
Stakeholder 2	CP	$(s_4, 0)$	$(s_4, 0)$	$(s_2, 0)$	$(s_4, -0.5)$
	UP	$(s_3, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_3, 0.25)$
	NSP	$(s_4, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_4, -0.35)$
	SL	$(s_4, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_4, -0.35)$
	OL	$(s_4, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_4, -0.35)$
	TS	$(s_4, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_4, -0.35)$
	C	$(s_3, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_3, 0.25)$
Stakeholder 3	CP	$(s_1, 0)$	$(s_2, 0)$	$(s_0, 0)$	$(s_1, 0.1)$
	UP	$(s_1, 0)$	$(s_2, 0)$	$(s_2, 0)$	$(s_2, -0.4)$
	NSP	$(s_2, 0)$	$(s_2, 0)$	$(s_1, 0)$	$(s_2, -0.25)$
	SL	$(s_2, 0)$	$(s_2, 0)$	$(s_3, 0)$	$(s_2, 0.25)$
	OL	$(s_2, 0)$	$(s_2, 0)$	$(s_2, 0)$	$(s_2, 0)$
	TS	$(s_1, 0)$	$(s_2, 0)$	$(s_3, 0)$	$(s_2, -0.15)$
	C	$(s_3, 0)$	$(s_2, 0)$	$(s_3, 0)$	$(s_3, -0.35)$
Stakeholder 4	CP	$(s_3, 0)$	$(s_4, 0)$	$(s_1, 0)$	$(s_3, -0.15)$
	UP	$(s_3, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_3, 0.25)$
	NSP	$(s_3, 0)$	$(s_3, 0)$	$(s_3, 0)$	$(s_3, 0)$
	SL	$(s_3, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_3, 0.25)$
	OL	$(s_3, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_3, 0.25)$
	TS	$(s_4, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_4, -0.35)$
	C	$(s_3, 0)$	$(s_3, 0)$	$(s_4, 0)$	$(s_3, 0.25)$

Next, the collective evaluation by attribute is aggregated to obtain a general evaluation by stakeholder. The WA operator is used in the aggregation process as it is considered that the attributes of the stakeholders have different relevance expressed in the weighted vector. Then, the 2-tuple comparison operator is used to establish the stakeholder's order. Table 7 shows the general evaluation of stakeholders aggregated by experts and attributes and a ranking list of project's stakeholders.

Table 7. Evaluation by stakeholder

Stakeholder	General evaluation	Order
Stakeholder 1	$(s_1, -0.2)$	4
Stakeholder 2	$(s_3, 0.4965)$	1
Stakeholder 3	$(s_2, -0.161)$	3
Stakeholder 4	$(s_3, 0.202)$	2

5.1 Comparison between the proposed approach and existing approaches for stakeholder prioritization

Table 8 shows a comparison between the proposed approach and the existing techniques for the stakeholder prioritization that were analyzed in section 2 of this research. It is used as comparison criteria between the different stakeholder prioritization approaches: the use of several attributes for stakeholder prioritization, the management of the uncertainty of the information provided by the experts, the use of multiple experts for the stakeholder evaluation and if the approach allows the information's aggregation provided by the experts to obtain a collective and unique assessment.

Table 8. Comparison between approaches for stakeholder prioritization

Criteria	Stakeholder prioritization approaches					
	Clarkson's approach	Friedman's approach	Gardner's approach	Savage's approach	Mitchell's approach	Proposed approach
Use of several attributes	No	Yes	Yes	Yes	Yes	Yes
Management of the uncertainty	No	No	No	No	No	Yes
Use of multiple experts	No	No	No	No	No	Yes
Aggregation of the information	No	No	No	No	No	Yes

6 Conclusions

Prioritization of project stakeholders is an important task because the success of a project depends largely on stakeholders. The handling of the uncertainty of information provided by the experts is an aspect to be taken into account in this process, since the more accurate be the information, the more accurate decisions can be taken with respect to the stakeholders. Current methods are not efficient in handling the uncertainty and assessment of multiple experts of stakeholder prioritization. In this paper, we have proposed a linguistic approach for stakeholder prioritization to overcome these limitations, by using the linguistic 2-tuple fusion model. The proposal is based on the CWW paradigm that allows obtaining more interpretable results firstly unifying the assessments of multiple experts into linguistic 2-tuple values and latter applying an accurate aggregation process that makes possible to generate a more exact priority for the stakeholder in the project.

7 Future work

As future work, the approach presented for stakeholder prioritization could be extended to use other more accurate and adjustable aggregation operators to this problem. It could also be taken into account that each expert could express their evaluations in different domains of expression, thus handling heterogeneous information. The experts could express their evaluations numerically, in an interval way or based on a set of linguistic labels of different cardinalities. An extension of the proposed approach would be presented as a solution to the treatment of heterogeneous information unifying the different domains of expression of expert evaluations.

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